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Evaluation of Hose-End Sprayers Used for Applying Liquid Pesticides

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Nineteen garden hose-end sprayers used for applying agricultural chemicals were evaluated for delivery rates, spray patterns, and total spray emitted per unit of time. Sprayers were evaluated at 137.88, 206.82, and 275.76 KPa (20, 30, and 40 psi) water pressures. Each sprayer type is discussed individually. Eight sprayer types had acceptable delivery rates (± 10%) at 137.88 and 206.82 KPa (20 and 30 psi) water pressures. Twelve sprayer types had acceptable delivery rates at 275.76 KPa (40 psi) water pressure. Delivery rate variation of other sprayer types ranged from no application of pesticide to 105% above the desired rate. Sprayer delivery volumes ranged from 1.86 to 12.66 liters (0.49 to 3.34 U. S. gallons) per minute. Spray patterns are shown for each sprayer type. Hose-end sprayers are easy to use, economical, and in some cases have acceptable accuracy when used as directed.

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EVALUATION OF HOSE-END SPRAYERS USED FOR APPLYING LIQUID PESTICIDES

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ABSTRACT

Nineteen garden hose-end sprayers used for applying agricultural chemicals were evaluated for delivery rates, spray patterns, and total spray emitted per unit of time. Sprayers were evaluated at 137.88, 206.82, and 275.76 KPa (20, 30, and 40 psi) water pressures. Each sprayer type is discussed individually.

Eight sprayer types had acceptable delivery rates (± 10%) at 137.88 and 206.82 KPa (20 and 30 psi) water pressures. Twelve sprayer types had acceptable delivery rates at 275.76 KPa (40 psi) water pressure. Delivery rate variation of other sprayer types ranged from no application of pesticide to 105% above the desired rate.

Sprayer delivery volumes ranged from 1.86 to 12.66 liters (0.49 to 3.34 U. S. gallons) per minute.

Spray patterns are shown for each sprayer type.

Hose-end sprayers are easy to use, economical, and in some cases have acceptable accuracy when used as directed.

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Key words: Sprayer evaluation, Hose-end sprayers, Pesticide sprayers, Home garden sprayers, Spray volume, Spray patterns, Delivery rates.

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SECTION I

INTRODUCTION

Garden hose-end sprayers are becoming more popular for home and garden application of insecticides, herbicides, fungicides and fertilizers. Due to consumer demand, an increasing number of these sprayers have been developed for specific and multiple uses. Hose-end sprayers are now commonly recommended on the labels of pesticide products.

A literature review did not reveal any information on the rate of application, spray pattern or any other parameters of these devices. Personal communication with manufacturing firms yielded no significant information either. This study was undertaken to examine hose-end sprayers for their: 1) delivery rates; 2) spray patterns; and 3) the total volume of spray emitted per unit of time.

In this manuscript each sprayer is placed in a separate section to broaden its utility. Under each section the following items are discussed: 1) Name of the device, its manufacturer or for whom the device is made; 2) Major features of the device; 3) Statistical analysis of delivery rate concentration obtained at several water pressures; 4) Statistical analysis of delivery rate concentration obtained between like devices; 5) Mathematical analysis of delivery rate concentration with expected concentration; 6) Volume of spray emitted per unit of time; and 7) Spray patterns produced by the sprayer.

SECTION II

CONCLUSIONS AND RECOMMENDATIONS

Hose-end sprayers are easy to use, economical, and in most cases have acceptable accuracy when used as directed.

For reasons of safety, efficacy, and environmental concerns a device used for the application of agricultural chemicals should be reasonably accurate. An unwritten rule among spray applicators is that the sprayer should deliver the product at a rate within 10% of the desired rate. Application rates outside this range are unacceptable.

In this study, eight sprayer types had acceptable range of application rate of $\pm$ 10% when using 20 and 30 psi water pressures and twelve were acceptable when using 40 psi water pressure. Others showed slight to considerable variation from the desired delivery rate. An over-application of 105% to no application at all of the product occurred within this group. More precise engineering of orifices would increase the accuracy in delivery rate.

Deflectors on some units rendered the spray patterns uneven. These deflectors need to be reexamined and the cause of their malfunctioning removed.

Some sprayers have such copious delivery volumes that the operator cannot keep up with the fast disappearing chemical in the container. This defect should and could easily be eliminated.

Devices that require placing the thumb or finger over a control hole are awkward to use. Also these same devices lack a shut-off control and therefore spray just water before the control hole is covered. This is an undesirable feature which should be rectified in order to minimize the wastage of water and more importantly to eliminate the possibility of wetting down the foliage before the application of mixed spray.

Many of the hose-end sprayers are recommended or allowed to be used for the application of a variety of agricultural chemicals including herbicides. These sprayers should have a cautionary statement to the users and some instructions in the method of cleaning them so that no herbicidal damage will result at their subsequent use for the application of other chemicals.

Only the Gilmour Air-O-Matic 362 sprayer has an anti-siphon built into the sprayer. This should be considered by other manufacturers to prevent possible contamination of domestic water supply.

Hose-end sprayers need further development and proper quality control to increase their usefulness to the pesticide users.

SECTION III

MATERIALS AND METHODS

Nineteen different garden hose-end sprayers, purchased locally or contributed by industry, were evaluated. Fourteen sprayer types were represented by three sprayers each. Because of unavailability, four sprayer types were represented by a single unit, and one sprayer type with two units. Most of the sprayers had one setting only, but a few had two or more. Those sprayers in which both liquid and wettable powder chemicals could be used were evaluated with liquid only.

The delivery rate for each sprayer was determined using three water pressures, i.e., 20 psi (137.88 KPa), 30 psi (206.82 KPa), and 40 psi (275.76 KPa) and by following sprayer label directions. The maximum tap water pressure at the test site was 53 psi (365.38 KPa). Due to the fluctuation in the tap water pressure and the lower limit of the regulator valve, 40 psi was set as the upper limit and 20 psi as the lower limit in water pressure used.

Water pressure was regulated using a Webster regulator valve No. 50 UB. The garden hose, regulator valve, gauge, and sprayer assembly is shown in Figure 1.

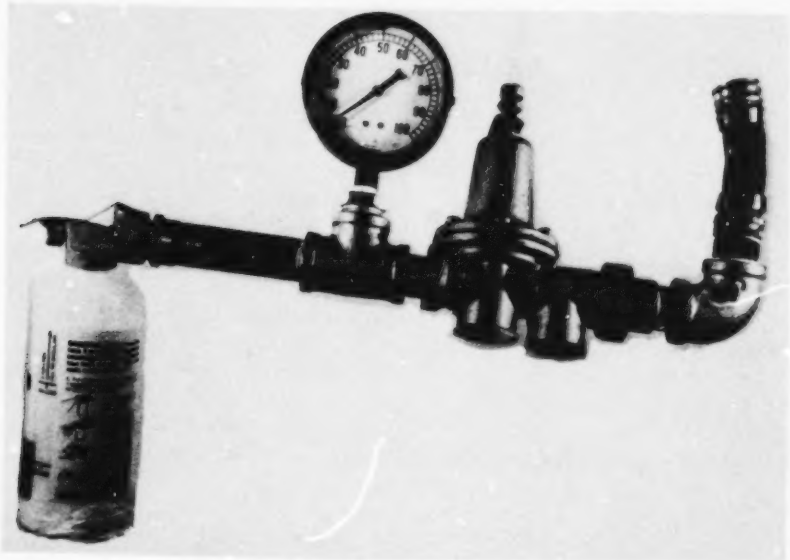

Figure 1. Garden hose, regulator valve, gauge, and sprayer assembly.

Spray delivery rate - Potassium permanganate ($KMnO_4$) at a concentration of 2,000 parts per million (ppm)(Wt/vol.) was used as the test material. Measured volumes of this stock solution and water were put into the container of each sprayer under test. The ratios between the chemical and water volumes were prescribed on the sprayer label. Water pressure was adjusted while the sprayer was turned on. Three samples of the emitted spray were collected for 3 seconds each. Each sample represented a replication. In the case of Gilmore Air-O-Matic 362 sprayer, however, only two samples were collected, and only $KMnO_4$ was placed in the sprayer container.

The optical density of each sample was determined on a Bausch and Lomb Spectronic 20 Spectrophotometer at the 525 mμ setting. The optical density reading was then converted to ppm concentration read from a previously constructed standard curve. This procedure was repeated for each sprayer at the three water pressure settings.

Spray patterns - Spray pattern for each sprayer was determined by placing a strong solution of methylene blue in the sprayer container. The target was blotting paper either 2 feet x 2.5 feet (0.61 m x 0.76 m) or 4 feet x 2.5 feet (1.22 m x 0.76 m) depending on the width of the emitted spray. The blotting paper was sprayed while holding the sprayer 5 feet (1.52 m) away and spraying with an upward sweeping motion. Thirty psi water pressure only was used in these determinations.

Delivered spray volumes - The total volume of spray delivered per unit of time was determined using 30 psi water pressure. Water alone was put into the sprayer container. The emitted spray was collected for 5 seconds in a conical flask and its volume determined. This procedure was repeated three times.

SECTION IV

ORTHO SPRAY-ETTE 4

Figure 2. Ortho Spray-ette 4

Ortho Spray-ette 4 (Figure 2) is manufactured for Chevron Chemical Company, Ortho Division. It was designed for applying herbicides, insecticides, fungicides, and fertilizers and has a maximum delivery capacity of 4 gallons of diluted spray. This device has an adjustable spray deflector for directing the spray in any direction. The pesticide must be mixed with water in the sprayer container, which allows both liquid and wettable powder pesticides to be used.

Forty-five ml of $KMnO_4$ stock solution and 450 ml of water were put into the sprayer container for determining delivery rate accuracy. This mixture should have allowed the emitted spray to equal 1 tablespoonful of pesticide per gallon of water. The delivery rates of sprayers did not vary significantly as a result of water pressure (Table 6). Individual sprayers were significantly different at the 5% level in delivery rates while using 20 psi water pressure (Table 3). Delivery rates of the sprayers were not significantly different at 30 and 40 psi water pressures (Tables 4 and 5).

Figure 3. Ortho Spray-ette 4 Spray pattern tested at 30 psi water pressure, at a distance of 5 feet.

Figure 4. New Ortho Spray-ette 4

Comparison of expected delivery rates and actual delivery rates obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm.

The mean volume of mixed spray delivered in 5 seconds was 177 ml (Table 2) and was equal to 0.56 U. S. gallon per minute.

The spray pattern of the Ortho Spray-ette 4 is shown in Figure 3.

The Ortho Spray-ette 4 does not have an on and off control. A suction must be created by placing the thumb over the control hole to properly mix chemical with water emitted. These deficiencies have been corrected by the New Ortho Spray-ette 4 (Figure 4) which was not evaluated.

SECTION V

ORTHO SUPER SIX SPRAY-ETTE

Figure 5. Ortho Super Six Spray-ette

Ortho Super Six Spray-ette (Figure 5) is manufactured for Chevron Chemical Company, Ortho Division. This sprayer was designed for the application of Ortho products such as herbicides and insecticides. It has a maximum delivery capacity of 4 gallons of diluted spray. It has an on and off control valve. The deflector is adjustable for directing the spray in all directions. The pesticide must be mixed with water in the sprayer container, which allows both liquid and wettable powder pesticides to be used.

One hundred and twenty ml of $KMnO_4$ stock solution and 490 ml of water were put into the sprayer container, bringing the solution to the 4-gallon mark on the container, for determining delivery rate accuracy. This mixture should have allowed the emitted spray to equal 2 tablespoonsful of pesticide per gallon of water. Delivery rates of sprayers did not vary significantly as a result of water pressure (Table 6). Sprayer 1 was significantly different in delivery rate from the other sprayers when using 20 psi water pressure (Table 3). Individual sprayers were significantly different in delivery rates at the 5% level while using 30 psi water pressure (Table 4). Individual sprayers were not significantly different in their delivery rates while using 40 psi water pressure (Table 5).

Comparison of expected delivery rates and actual delivery rates obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates of this sprayer ranged from 40 to 42% below the expected delivery rate and were unacceptable.

The mean volume of mixed spray delivered in 5 seconds was 158 ml (Table 2) and was equal to 0.5 U. S. gallon per minute.

The spray pattern of the Ortho Super Six Spray-ette is shown in Figure 6.

Figure 6. Ortho Super Six Spray-ette spray pattern tested at 30 psi water pressure, at a distance of 5 feet.

SECTION VI

ORTHO LAWN SPRAYER

Figure 7. Ortho Lawn Sprayer

Ortho Lawn Sprayer (Figure 7) is manufactured for Chevron Chemical Company, Ortho Division. This sprayer was designed to apply liquid fertilizers, herbicides, and soil insecticides. It has a maximum delivery capacity of 15 gallons of diluted spray. Chemical and water must be mixed in proper proportions in the sprayer container, which allows both liquid and wettable powder chemicals to be used.

One hundred and twenty ml of $KMnO_4$ stock solution and 390 ml of water were put into the sprayer container for determining delivery rate accuracy. This mixture should have allowed the emitted spray to equal 1 tablespoonful of chemical per gallon of water. The delivery rates of the sprayers did not vary significantly as a result of water pressure (Table 6). Individual sprayers did vary significantly at the 5% level from one another in delivery rate at all three water pressures (Tables 3, 4, and 5). Only two sprayers were available for evaluation.

Comparison of expected delivery rates and actual delivery rates are given in Table 1, along with the percent error and the deviation from the

expected values in ppm. The delivery rates of this sprayer ranged from 4 to 8% above the expect delivery rate and were within the acceptable range.

The mean volume of mixed spray delivered in 5 seconds was 1,055 ml (Table 2) and was equal to 3.34 U. S. gallons per minute.

The spray pattern of the Ortho Lawn Sprayer is shown in Figure 8.

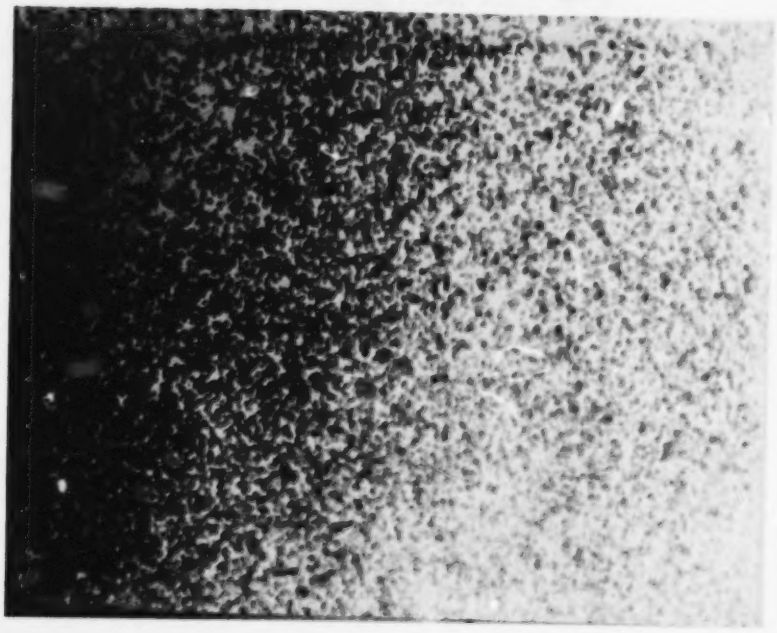

Figure 8. Ortho Lawn Sprayer spray pattern tested at 30 psi water pressure, at a distance of 5 feet.

This sprayer's deficiencies are: The absence of an on and off control; a suction must be created by placing the thumb over a control hole to mix chemical with emitted water; and the spray pattern is fixed by the sprayer nozzle.

SECTION VII

ORTHO LAWN AND GARDEN SPRAYER

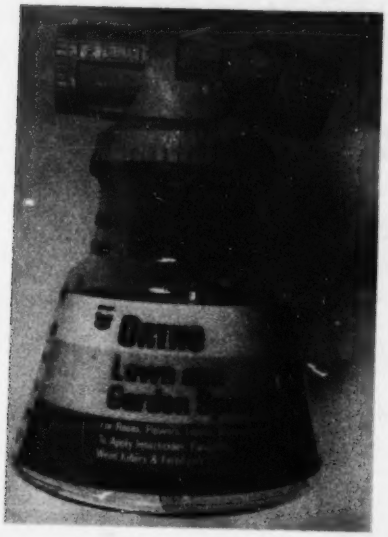

Figure 9. Ortho Lawn and Garden Sprayer

Ortho Lawn and Garden Sprayer (Figure 9) is manufactured for Chevron Chemical Company, Ortho Division. This sprayer was designed to apply insecticides, fungicides, herbicides, and fertilizers to shrubs, flowers, lawns, and trees. The sprayer has four settings. "Up Foliage and Foliage" setting is used to spray the under side of leaves. "Down Foliage and Foliage" is used to spray the top side of leaves and lawn grasses. "Jet Foliage and Foliage" setting is used for spraying large shrubs and trees. "Down Soil and Soil" setting is used to apply insecticides and fertilizers to the soil. The deflector for each setting is built into the sprayer. This sprayer has an on and off control. A button for filling the sprayer container without disconnecting the garden hose is available on this unit.

The accuracy of this sprayer's delivery rate at three water pressures and two settings was determined by putting 120 ml of $KMnO_4$ stock solution and 490 ml of water into the sprayer container. This mixture should have allowed the emitted spray to equal 2 tablespoonsful of chemical per gallon of water.

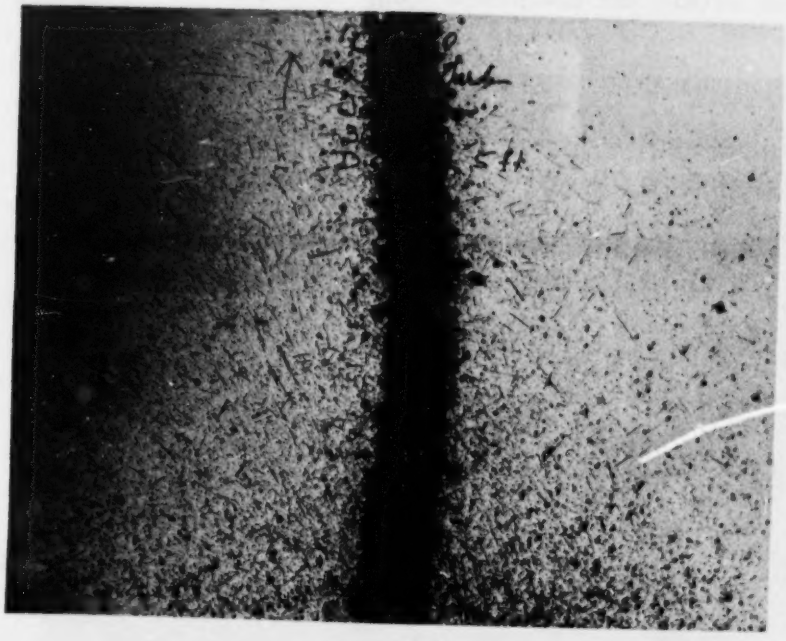

Figure 10. Ortho Lawn and Garden Sprayer spray pattern tested at the setting "Jet Foliage and Foliage," when using 30 psi water pressure, at a distance of 5 feet.

No significant differences were found in the delivery rates, at the "Down Foliage and Foliage" setting, as a result of water pressure (Table 6). All individual sprayers were different in delivery rates when using 20 psi water pressure (Table 3). Sprayer 1 was significantly different in delivery rate from sprayer 3 when using 30 psi water pressure (Table 4). Sprayer 3 was significantly different in delivery rate from the other two sprayers while using 40 psi water pressure (Table 5).

At the setting of "Down Soil and Soil," no significant differences between delivery rates were observed due to water pressure (Table 6). Sprayer 2 had a delivery rate which was significantly different from the other sprayers while using 20 psi water pressure (Table 3). No significant differences in delivery rates of individual sprayers existed while using 30 and 40 psi water pressure (Tables 4 and 5).

"Up Foliage and Foliage" and "Jet Foliage and Foliage" settings were not evaluated for delivery rate accuracy in this study.

Comparison of expected delivery rates and actual delivery rates obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates of this sprayer at the "Down Soil and Soil" setting ranged from 57 to 58% below the expected delivery rate and were unacceptable. The delivery rates of this sprayer at the "Down

Foliage and Foliage" setting ranged from 4 to 6% below the expected delivery rate and were within the acceptable range of ± 10%.

Figure 11. Ortho Lawn and Garden Sprayer spray pattern tested at the setting "Up Foliage and Foliage," while using 30 psi water pressure, at a distance of 5 feet.

The mean volume of mixed spray delivered in 5 seconds was 492 ml (1.56 U. S. gallons per minute) and 183 ml (0.58 U. S. gallon per minute) when using "Down Soil and Soil" and "Down Foliage and Foliage" settings respectively (Table 2).

The spray patterns of the Ortho Lawn and Garden Sprayer are shown in Figures 10 and 11.

SECTION VIII

NEW HAYES INSECTICIDE SPRAYER NO. 101

Figure 12. New Hayes Insecticide Sprayer No. 101

New Hayes Insecticide Sprayer No. 101 (Figure 12) is manufactured by Hayes Products Division of The Leisure Group, Inc. This sprayer was designed for applying insecticides and has a maximum delivery capacity of 3 gallons of diluted spray. It has an adjustable deflector for spraying in any direction. The chemical must be mixed with water in the sprayer container, allowing both liquid and wettable powder chemical use.

Ninety ml of $KMnO_4$ stock solution and 385 ml of water were put into the sprayer container for determining delivery rate accuracy. This should allow the emitted spray to equal 2 tablespoonsful of chemical per gallon of water. Delivery rates of the sprayers did not vary significantly as a result of water pressure (Table 6). One of three individual sprayers was significantly different in delivery rate at each of the three water pressures tested (Tables 3, 4, and 5).

Comparison of expected delivery rates and actual delivery rates obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates of this sprayer ranged from

11 to 12% below the expected delivery rate and were only marginally acceptable.

The mean volume of mixed spray delivered in 5 seconds was 185 ml (Table 2) and was equal to 0.59 U. S. gallon per minute.

The spray pattern for this sprayer is shown in Figure 13.

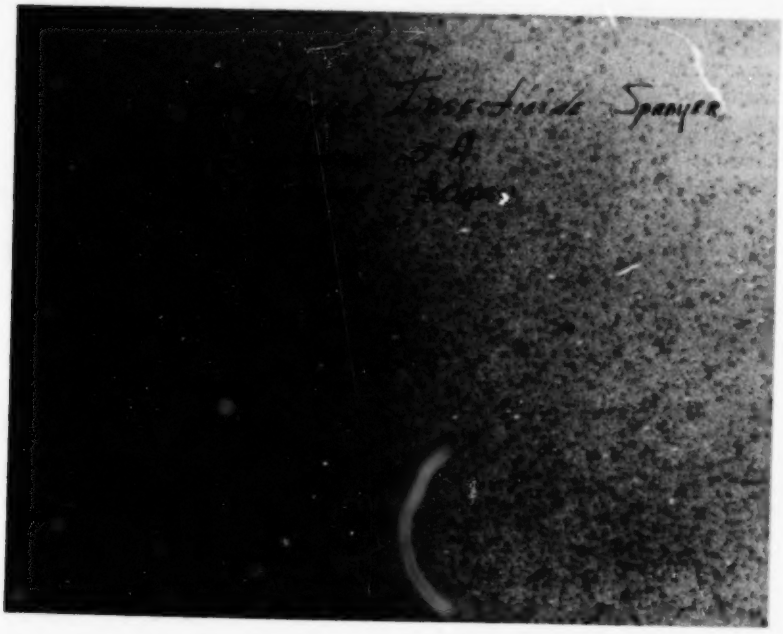

Figure 13. New Hayes Insecticide Sprayer No. 101 spray pattern tested at 30 psi water pressure, at a distance of 5 feet.

This sprayer's deficiencies are: the absence of an on and off control; and a suction must be created by placing the thumb over a control hole to mix chemical with emitted water.

SECTION IX

HAYES FLOWER SPRAYER NO. H-4

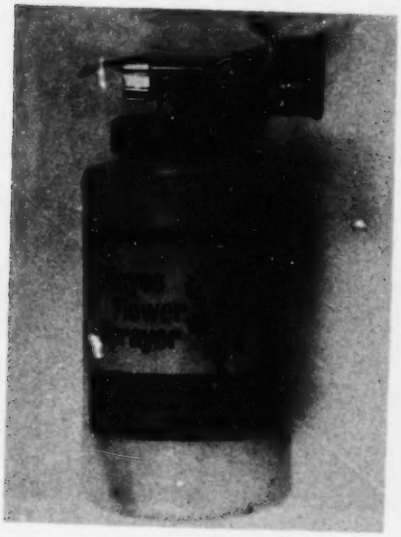

Figure 14. Hayes Flower Sprayer No. H-4

Hayes Flower Sprayer No. H-4 (Figure 14) is manufactured by Hayes Products Division of The Leisure Group, Inc. It is an all-purpose fertilizer and insecticide sprayer for all garden flowers, plants, shrubs, and trees, and has a maximum delivery capacity of 4 gallons of diluted spray. This sprayer has an on and off control as well as an adjustable spray deflector for spraying in any direction.

Ninety ml of $KMnO_4$ stock solution and 375 ml of water were put into the sprayer container for determining delivery rate accuracy. This mixture should allow the emitted spray to equal 2 tablespoonsful of chemical per gallon of water. Delivery rates of the sprayers did not vary significantly due to water pressure (Table 6). Individual sprayers were significantly different from one another in delivery rates while using 20 psi water pressure (Table 3). One sprayer of the three tested was significantly different in delivery rates while using 30 and 40 psi water pressures (Tables 4 and 5).

Comparison of expected delivery rates and actual delivery rates obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. This sprayer was outstandingly accurate.

The spray pattern for this sprayer is shown in Figure 15.

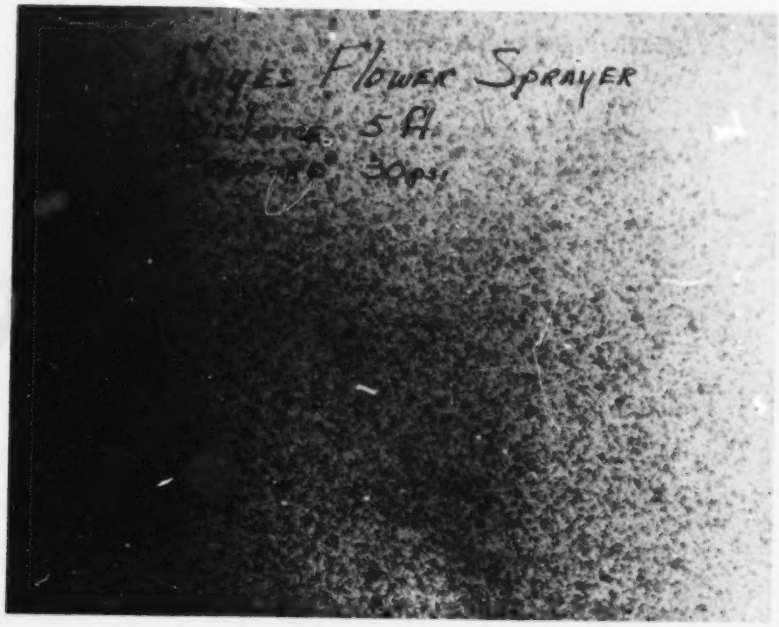

Figure 15. Spray pattern delivered by the Hayes Flower Sprayer No. H-4 when using 30 psi water pressure, at a distance of 5 feet.

The mean volume of mixed spray delivered in 5 seconds was 175 ml (Table 2) and was equal to 0.55 U. S. gallon per minute.

SECTION X

HAYES SOIL AND TURF SPRAYER NO. H-10

Figure 16. Hayes Soil and Turf Sprayer No. H-10

Hayes Soil and Turf Sprayer No. H-10 (Figure 16) is manufactured by Hayes Products Division of The Leisure Group, Inc. It has a maximum delivery capacity of 10 gallons of diluted spray and is used for spraying fertilizers, soil chemicals, heavy viscous materials, and herbicides. This sprayer has a fixed deflector directing the spray downward. The chemical is mixed with water in the sprayer container, allowing both liquid and wettable powder chemicals to be used.

One hundred and fifty ml of $KMnO_4$ stock solution and 290 ml of water were put into the sprayer container for determining delivery rate accuracy. This mixture should equal 2 tablespoonsful of chemical per gallon of water in the emitted spray. Delivery rates of the sprayers did not vary significantly as a result of water pressure (Table 6). The delivery rates of all individual sprayers were significantly different while using 20 and 40 psi water pressures (Tables 3 and 5), and one sprayer of the three tested was significantly different when using 30 psi water pressure (Table 4).

Comparison of expected delivery rates and actual delivery rates obtained are given in Table 1, along with the percent error and the deviation from

the expected values in ppm. The delivery rates of this sprayer ranged from 9 to 7% above the expected delivery rate when using 30 and 40 psi water pressure respectively and were within the acceptable range; however, at 20 psi water pressure, the sprayer delivered 21% above the expected rate and was unacceptable.

The mean volume of mixed spray delivered in 5 seconds was 885 ml (Table 2) and was equal to 2.81 U. S. gallons per minute.

The spray pattern consisted of large droplets and is shown in Figure 17.

Figure 17. Spray pattern of Hayes Soil and Turf Sprayer No. H-10 when tested using 30 psi water pressure, at a distance of 5 feet.

This sprayer does not have an on and off control; therefore, water is sprayed until covering the control hole with the thumb.

SECTION XI

HAYES FERTILIZER SPRAYER NO. 102

Figure 18. Hayes Fertilizer Sprayer No. 102

Hayes Fertilizer Sprayer No. 102 (Figure 18) is manufactured by Hayes Products Division of The Leisure Group, Inc. This sprayer is used to apply fertilizers to lawns and gardens as well as semi-soluble and viscous solutions. It has a maximum spray delivery capacity of 20 gallons. Chemicals used in this sprayer must be diluted with water in the sprayer container, allowing both liquid and wettable powder chemical use.

One hundred and fifty ml of $KMnO_4$ stock solution and 315 ml of water were put into the sprayer container for determining delivery rate accuracy and would allow the emitted spray dilution to equal 1 tablespoonful of chemical per gallon of water. Delivery rates of the sprayers did not vary significantly as a result of water pressure (Table 6). One of three sprayers had a significantly different delivery rate while using three water pressures tested (Tables 3, 4, and 5).

Comparison of expected delivery rates and delivery rates actually obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates of this sprayer ranged

from 11 to 34% above the expected delivery rate and were unacceptable.

The mean volume of mixed spray delivered in 5 seconds was 875 ml (Table 2) and was equal to 2.77 U. S. gallons per minute.

The spray pattern for this sprayer is shown in Figure 19.

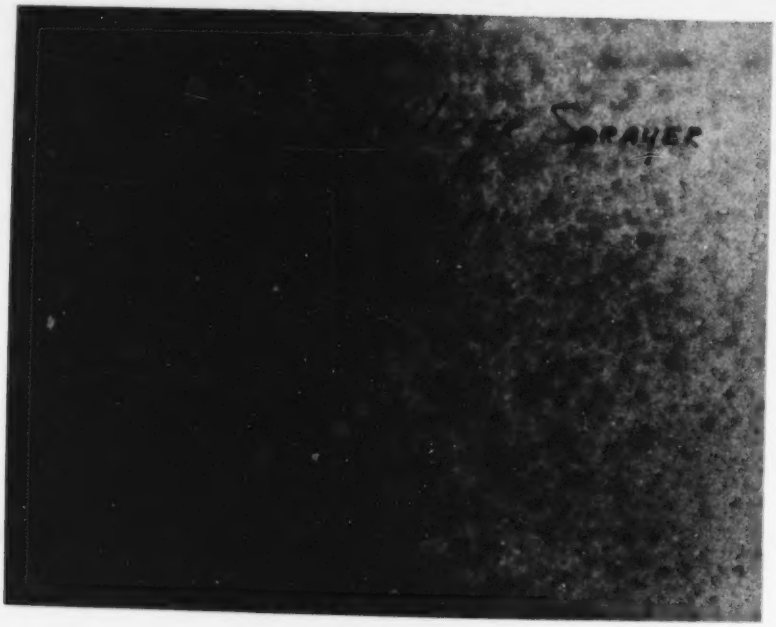

Figure 19. Spray pattern of the Hayes Fertilizer Sprayer No. 102 when tested using 30 psi water pressure, at a distance of 5 feet.

This sprayer does not have an on and off control.

SECTION XII

MILLER'S SIX SHOOTER HOSE-END SPRAYER

Figure 20. Miller's Six Shooter Hose-end Sprayer

Miller's Six Shooter Hose-end Sprayer (Figure 20) is manufactured by The Chas. H. Lilly Company. This sprayer is used to apply insecticides, fungicides, and fertilizers to trees, gardens, flowers, and shrubs. The sprayer is equipped with an on and off control and an adjustable deflector for spraying in any direction. The chemical is mixed with water in the sprayer container, allowing both liquid and wettable powder use.

Sixty ml of $KMnO_4$ stock solution and 310 ml of water were put into the sprayer container for determining delivery rate accuracy. This mixture should allow the emitted spray to equal 2 tablespoonsful of chemical per gallon of water. Delivery rates of the sprayers were significantly effected by 20 psi water pressure (Table 6). No significant difference in delivery rates of individual sprayers resulted from water pressures of 20 and 30 psi (Tables 3 and 4). One of the three sprayers was significantly different in delivery rate while using 40 psi water pressure (Table 5).

Comparison of expected delivery rates and delivery rates actually obtained are given in Table 1, along with the percent error and the deviation

from the expected values in ppm. The delivery rate, at 20 psi water pressure, was 4% below the expected value and was within the acceptable range. However, the delivery rates at 30 and 40 psi water pressures were 13 and 16% below the expected value and were marginally acceptable.

The mean volume of mixed spray delivered in 5 seconds was 318 ml (Table 2) and was equal to 1.01 U. S. gallons per minute.

The spray pattern for this sprayer is shown in Figure 21.

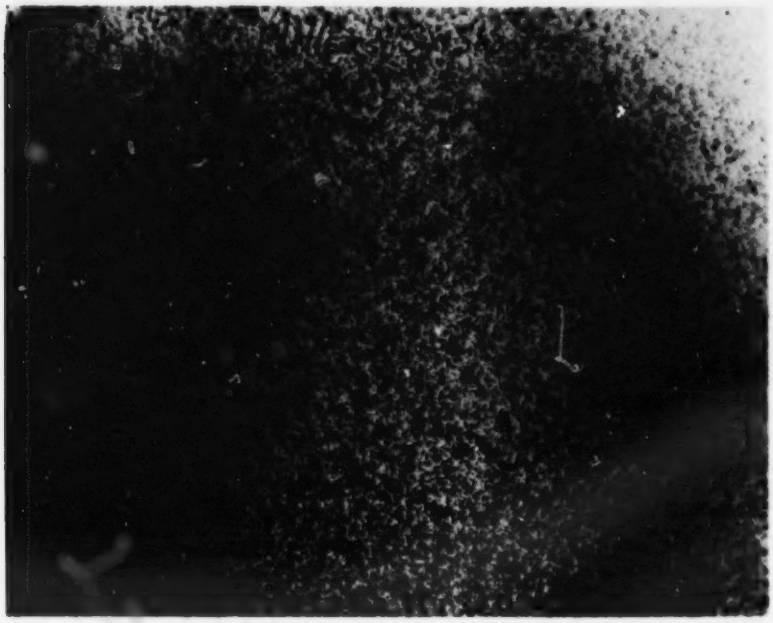

Figure 21. Spray pattern of Miller's Six Shooter Hose-end Sprayer when tested at 30 psi water pressure, at a distance of 5 feet.

SECTION XIII

MILLER'S BIG 15 HOSE-END SPRAYER

Figure 22. Miller's Big 15 Hose-end Sprayer

Miller's Big 15 Hose-end Sprayer (Figure 22) is manufactured by The Chas. H. Lilly Company. It has a maximum delivery capacity of 15 gallons of diluted spray and was designed for applying liquid fertilizers, herbicides, and soil insecticides to lawns, flower beds, and large areas. This sprayer has an on and off control; an adjustable deflector for directing the spray in any direction; and the chemical is mixed with water in the sprayer container, allowing both liquid and wettable chemical use.

One hundred and twenty ml of $KMnO_4$ stock solution and 185 ml of water were put into the sprayer container for determining delivery rate accuracy. This mixture was equal to 2 tablespoonsful of chemical per gallon of water. Delivery rates of the sprayer did not vary significantly as a result of water pressure (Table 6). One of three sprayers was significantly different in delivery rate while using 20 and 40 psi water pressures (Tables 3 and 5). All sprayers were significantly different in their delivery rates while using 30 psi water pressure (Table 4).

Comparison of expected delivery rates and delivery rates actually obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. All values were within the acceptable range of $\pm$ 10%. This sprayer was outstandingly accurate.

The mean volume of mixed spray delivered in 5 seconds was 388 ml (Table 2) and was equal to 1.23 U. S. gallons per minute.

The spray pattern of this sprayer is shown in Figure 23.

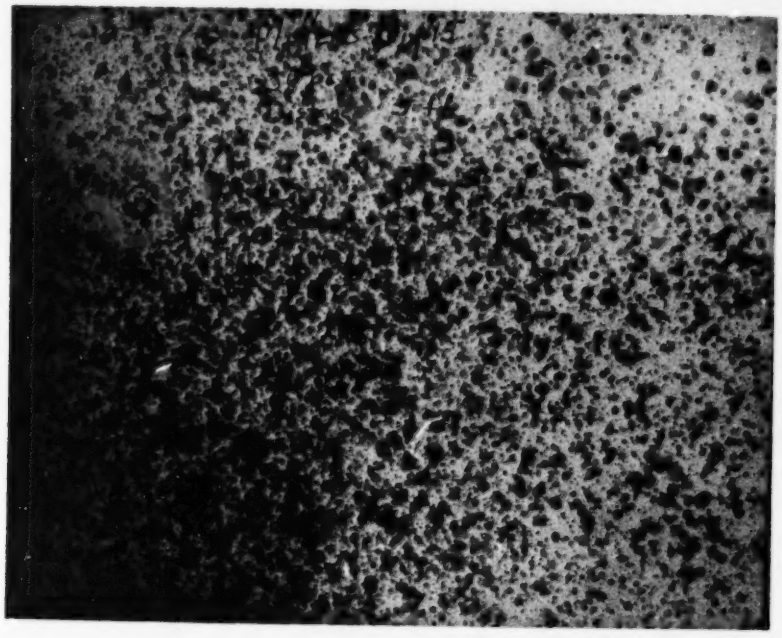

Figure 23. Spray pattern of Miller's Big 15 Hose-end Sprayer when tested using 30 psi water pressure, at a distance of 5 feet.

SECTION XIV

BURGESS REDIMIX 6 GALLON HOSE-END PLANT, SHRUB, AND TREE SPRAYER

Figure 24. Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer

Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer (Figure 24) is manufactured by Burgess Vibrocrafters, Inc. It has a maximum delivery capacity of 6 gallons of diluted spray and was designed for applying liquid insecticides, plant foods, and fungicides to plants, shrubs, fruit trees, and ornamentals. It has an on and off control and a fixed spray deflector.

Sixty ml of $KMnO_4$ stock solution and 232 ml of water were put into the sprayer container for determining delivery rate accuracy and should equal 2 tablespoonsful of chemical per gallon of water in the emitted spray. Delivery rates of the sprayer did not vary significantly as a result of water pressure (Table 6). One of three sprayers was significantly different in delivery rate at the three water pressures tested (Tables 3, 4, and 5).

Comparison of expected delivery rates and delivery rates actually obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. This sprayer was outstandingly accurate and all values were within the acceptable range of $\pm$ 10%.

The mean volume of mixed spray delivered in 5 seconds was 273 ml (Table 2) and was equal to 0.87 U. S. gallon per minute.

The spray pattern of this sprayer is shown in Figure 25.

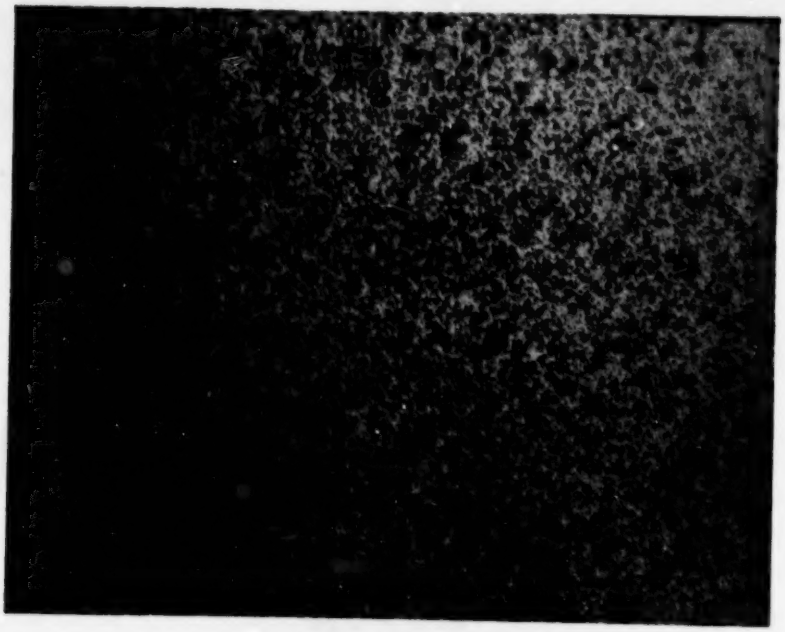

Figure 25. Spray pattern of Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer when tested using 30 psi water pressure, at a distance of 5 feet.

SECTION XV

BURGESS 3 IN 1 REDIMIX HOSE-END ALL PURPOSE SPRAYER

Figure 26. Burgess 3 in 1 Redimix Hose-End All Purpose Sprayer

Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer (Figure 26) is manufactured by Burgess Vibrocrafters, Inc. It has a maximum delivery capacity of 2, 6, or 15 gallons of diluted spray depending on the nozzle setting with the same numbers. This sprayer was designed for applying insecticides, fertilizers, plant foods, fungicides, and herbicides to lawns, gardens, and trees. The 6 nozzle is used for gardens, shrubs, and trees, while the 15 nozzle is used to spray lawns. For wettable powders the 2 nozzle is used.

Only the 6 and 15 nozzle settings were evaluated in this study.

Nozzle 6 Evaluation - One hundred and twenty ml of $KMnO_4$ stock solution and 500 ml of water were put into the sprayer container for determining delivery rate accuracy and should equal 2 tablespoonsful of chemical per gallon of water in the emitted spray. Delivery rates of the sprayer did not vary significantly as a result of water pressure (Table 6). One of three sprayers was significantly different in the delivery rate while using 20 and 40 psi water pressures (Tables 3 and 5). All sprayers were significantly different in delivery rates from one another while using 30 psi water pressure (Table 4).

Nozzle 15 Evaluation - Three hundred ml of $KMnO_4$ stock solution and 320 ml of water were put into the sprayer container for determining delivery rate accuracy of the 15 nozzle and should equal 2 tablespoonsful of chemical per gallon of water in the emitted spray. Delivery rates of the sprayers did not vary significantly as a result of water pressure (Table 6). All sprayers were significantly different in delivery rates while using 20 psi water pressure (Table 3). One of three sprayers was significantly different in delivery rate while using 30 and 40 psi water pressures (Tables 4 and 5).

Comparison of expected delivery rates and the delivery rates actually obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates ranged from acceptable to marginal in accuracy.

The spray patterns of this sprayer for both the 6 and 15 nozzle are shown in Figures 27 and 28.

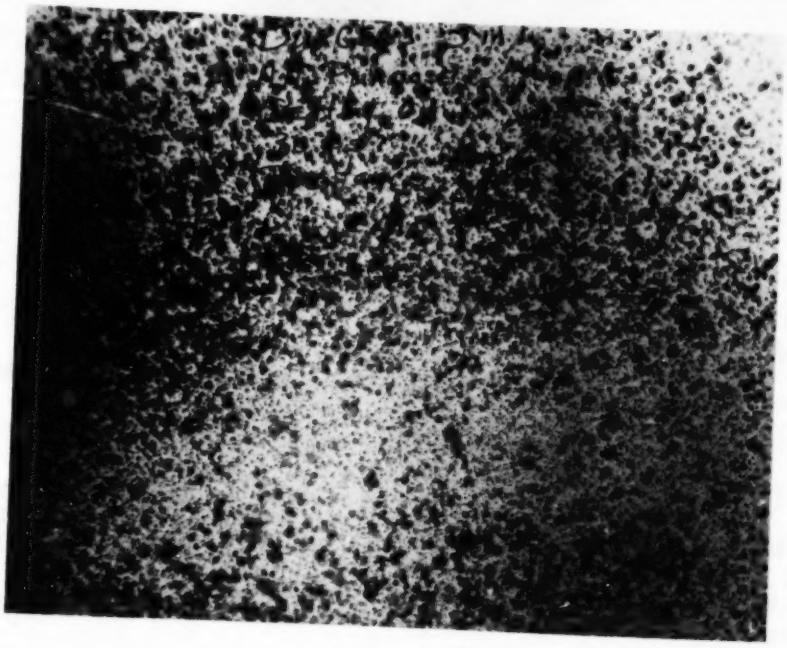

Figure 27. Spray pattern of the Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer when tested using the No. 6 nozzle, 30 psi water pressure, at a distance of 5 feet.

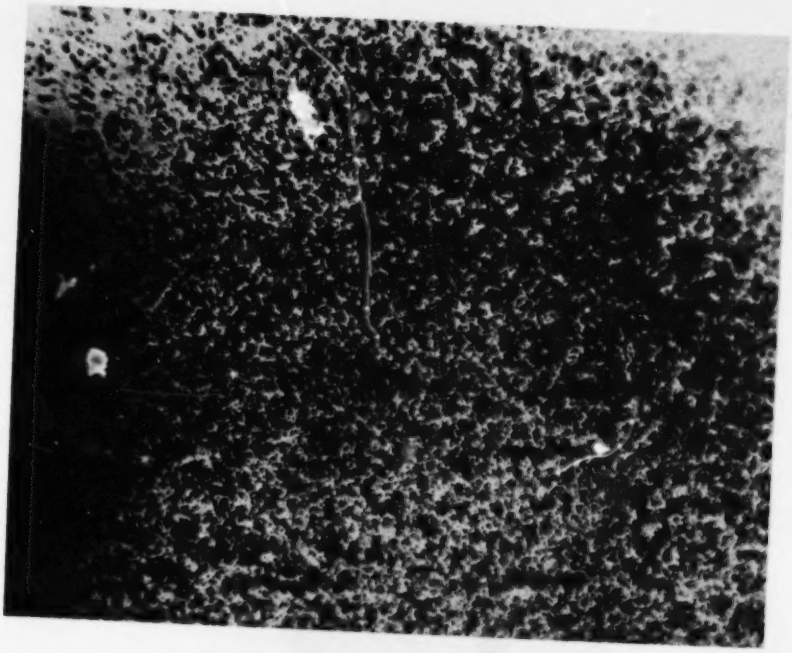

Figure 28. Spray pattern of the Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer when tested using the No. 15 nozzle, 30 psi water pressure, at a distance of 5 feet.

The mean volume of mixed spray delivered in 5 seconds was 287 ml (0.91 U. S. gallon per minute) when using the 6 nozzle, and 445 ml (1.41 U. S. gallons per minute) when using the 15 nozzle (Table 2).

SECTION XVI

BIG ANDY 20 GALLON FERTILIZER SPRAYER NO. A-21

Figure 29. Big Andy 20 Gallon Fertilizer Sprayer No. A-21

Big Andy 20 Gallon Fertilizer Sprayer No. A-21 (Figure 29) is manufactured by Hayes Products Division of The Leisure Group, Inc. The manufacturer is listed as Anderson Manufacturing Company on the sprayer label. The only direction for use on this sprayer label is "See fertilizer manufacturer's instruction for mixing."

One hundred and fifty ml of $KMnO_4$ stock solution and 300 ml of water were put into the sprayer container for determining delivery rate accuracy. Delivery rates of the sprayer did not vary statistically as a result of water pressure (Table 6). All sprayers were significantly different in delivery rates when using 20 psi water pressure (Table 3). One of three sprayers was significantly different in delivery rate while using 30 and 40 psi water pressures (Tables 4 and 5).

Comparison of expected delivery rates and delivery rates actually obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates of this sprayer ranged from 72 to 105% above the expected delivery rate and were totally unacceptable.

The mean volume of mixed spray delivered in 5 seconds was 1,283 ml (Table 2) and was equal to 4.07 U. S. gallons per minute.

The spray pattern of this sprayer is shown in Figure 30.

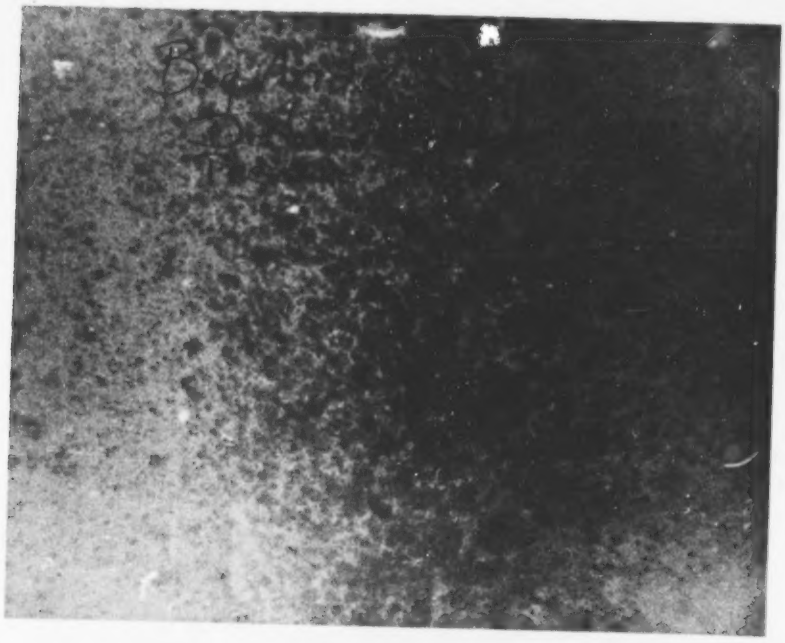

Figure 30. Spray pattern of the Big Andy 20 Gallon Fertilizer Sprayer No. A-21 when tested using 30 psi water pressure, at a distance of 5 feet.

Deficiencies of this sprayer are: lack of proper directions and cautions for use on the sprayer label; absence of an on and off control; a suction must be created by placing the finger over a control hole; water only is sprayed as soon as the tap is turned on; and the sprayer has a fixed spray deflector.

SECTION XVII

BIG ANDY 6 GALLON INSECTICIDE SPRAYER NO. A-7

Figure 31. Big Andy 6 Gallon Insecticide Sprayer No. A-7

Big Andy 6 Gallon Insecticide Sprayer No. A-7 (Figure 31) is manufactured by Hayes Products Division of The Leisure Group, Inc. The manufacturer is listed on the sprayer label as Anderson Manufacturing Company. The only direction for use on the sprayer label is "See Insecticide manufacturer's instructions for mixing."

One hundred and twenty ml of $KMnO_4$ stock solution and 520 ml of water were put into the sprayer container for determining delivery rate accuracy. Delivery rates of the sprayer did not vary statistically as a result of water pressure (Table 6). All sprayers were significantly different from one another in their delivery rates when using 20 and 40 psi water pressures (Tables 3 and 5). One of three sprayers was significantly different in delivery rate when using 30 psi water pressure (Table 4).

Comparison of expected delivery rates and delivery rates actually obtained are given in Table 1, along with the percent error and the deviation from the expected values in ppm. When using 20 psi water pressure, the sprayer was within the acceptable accuracy range of $\pm$ 10%; however, when using 30 and 40 psi water pressures the accuracy was marginal.

The mean volume of mixed spray delivered in 5 seconds was 155 ml (Table 2) and was equal to 0.49 U. S. gallon per minute.

The spray pattern of this sprayer is shown in Figure 32.

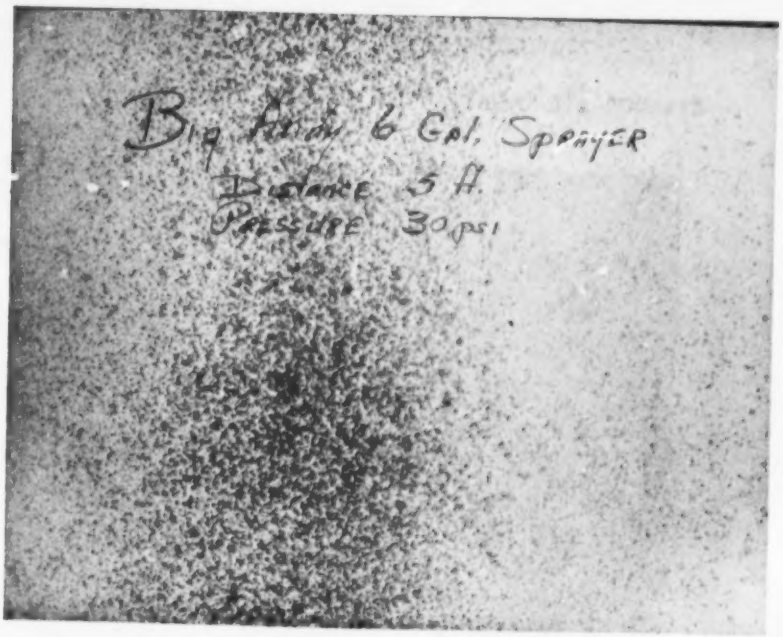

Figure 32. Spray pattern of the Big Andy 6 Gallon Insecticide Sprayer No. A-7 when tested using 30 psi water pressure, at a distance of 5 feet.

Deficiencies of this sprayer are: lack of proper directions and cautions for use on the sprayer label; absence of an on and off control; a suction must be created by placing the finger over a control hole; water only is sprayed as soon as the tap is turned on; and the sprayer has a fixed spray deflector.

SECTION XVIII

GILMOUR AIR-O-MATIC 362 SPRAYER

Figure 33. Gilmour Air-O-Matic 362 Sprayer

Gilmour Air-O-Matic 362 Sprayer (Figure 33) is manufactured by Gilmour Manufacturing Company. It was designed for spraying insecticides, fertilizers, herbicides, disinfectants, and detergents. Sprayer may be used on all types of plants. Both teaspoon and tablespoon rates may be used. This sprayer has several settings. No pre-mix of water and chemical is needed. All mixing of chemical and water takes place in the mixing head. It has an adjustable deflector for spraying in all directions. An anti-siphon device is built into the sprayer. The sprayer is easily controlled by an on and off trigger.

To determine the delivery rate accuracy of this sprayer, $KMnO_4$ stock solution only was put into the sprayer container. Only tablespoon rates were evaluated. The effects of water pressure on delivery rates at each of the sprayer settings are given in Table 6. Table 3 shows the difference in delivery rates between sprayers tested at each of the sprayer settings, when using 20 psi water pressure. Table 4 shows the difference in delivery rates between sprayers tested at each of the sprayer settings when using 30 psi water pressure. Table 5 shows the difference in delivery rates between

sprayers tested at each of the sprayer settings when using 40 psi water pressure.

Comparison of expected delivery rates and delivery rates actually obtained at each sprayer setting are given in Table 1, along with the percent error and the deviation from the expected values in ppm. The delivery rates of this sprayer at all settings ranged from 14 to 100% below the expected values, when using 20 psi water pressure and were all unacceptable. The sprayer delivery rates at all settings, when using 30 psi water pressure ranged from 4 to 43% below the expected values, and only one setting gave an acceptable value. The delivery rates of this sprayer at all settings ranged from 25% below to 30% above the expected values, when using 40 psi water pressure, and 5 values were within the acceptable range of $\pm$ 10%.

The mean volume of mixed spray delivered in 5 seconds when using sprayer settings 2, 6, or 10 and 30 psi water pressure are given in Table 2. The delivery rate range was from 360 to 380 ml which is equal to 1.14 to 1.2 U. S. gallons per minute.

The spray pattern of this sprayer was determined at the 3 setting, while using 30 psi water pressure, at a distance of 5 feet and is shown in Figure 34.

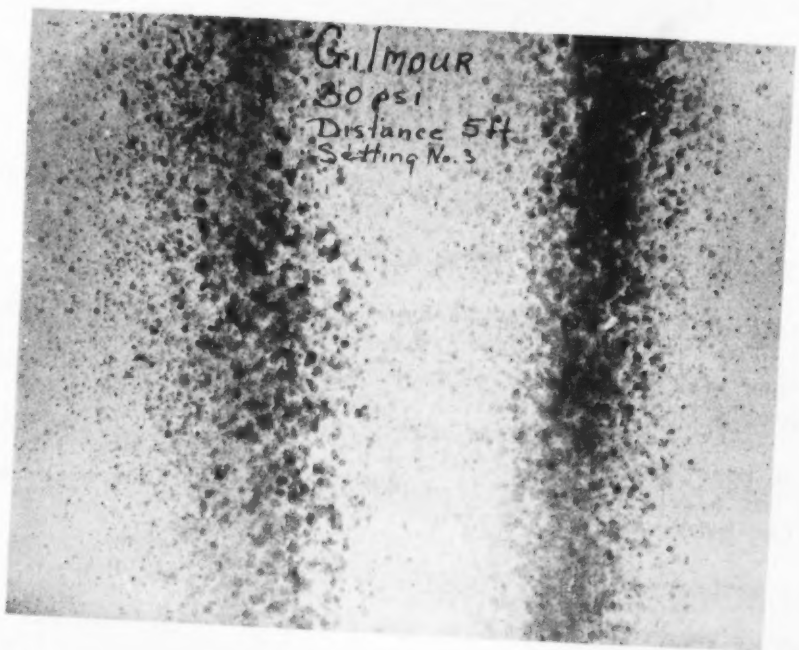

Figure 34. Spray pattern of the Gilmour Air-O-Matic 362 Sprayer when tested at the 3 setting, using 30 psi water pressure, at a distance of 5 feet.

This sprayer does not function at low pressures and the sprayer is inaccurate at most settings tested.

SECTION XIX

MELNOR DELUXE ALL-PURPOSE GARDEN GUN

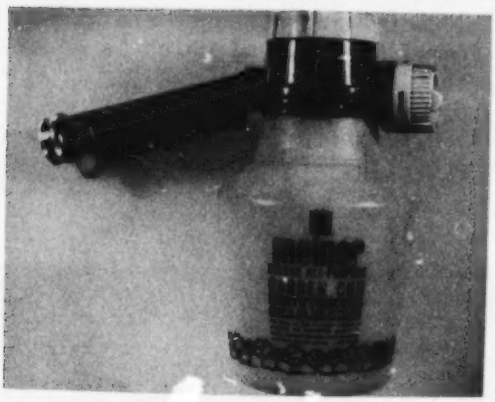

Figure 35. Melnor Deluxe All-Purpose Garden Gun

Melnor Deluxe All-Purpose Garden Gun (Figure 35) is manufactured by Melnor Industries. It was designed for spraying gardens, flowers, shrubs, lawns, and trees with pesticides. Sprayer label recommends following chemical manufacturer's instructions in use of pesticides. This sprayer has 2 settings of 6 or 15 gallons maximum of emitted spray. The deflector is built into the nozzle turret and has four adjustments of wide, narrow, shrub, and jet. It has a setting for filling the sprayer container with water while attached to the garden hose.

A single sprayer unit only was available for evaluation.

Sixty ml of $KMnO_4$ stock solution and 240 ml of water were put into the sprayer container for determining the delivery rate accuracy at the 6 gallon setting. The mean delivery rate values of 3 collections were 3.5, 6.83, and 7.33 ppm at 20, 30, and 40 psi water pressures respectively. The expected delivery rate value was 15.9 ppm. Delivery rate errors for 20, 30, and 40 psi water pressures were 78, 57, and 54% below the expected value respectively. The ppm values below the expected value were 12.4, 9.0, and 8.5 ppm at 20, 30, and 40 psi water pressures respectively.

One hundred and fifty ml of $KMnO_4$ stock solution and 150 ml of water were put into the sprayer container for determining the delivery rate accuracy at the 15 setting. The mean delivery rate values of 3 collections were 8.33, 9.83, and 10.0 ppm at 20, 30, and 40 psi water pressures respectively. The expected delivery rate value was 15.9 ppm. Delivery rate errors for 20, 30, and 40 psi water pressures were 47, 38, and 37% below the expected value respectively. The values in ppm below the expected value were 7.5, 6.0, and 5.9 ppm respectively. This sprayer's delivery rates were unacceptable.

The mean volume of mixed spray delivered in 5 seconds were: 303 ml and equal to 0.96 U. S. gallon per minute, at the 6 setting; and 335 ml and equal to 1.06 U. S. gallons per minute, at the 15 setting.

Some of the spray patterns are shown in Figures 36, 37, 38, and 39.

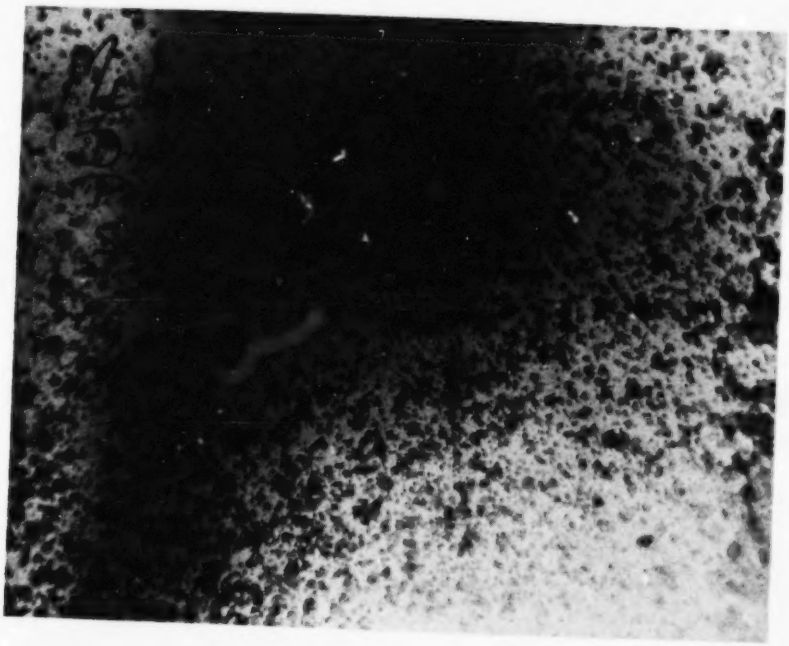

Figure 36. Spray pattern of the Melnor Deluxe All-Purpose Garden Gun when tested using the 6 setting, Shrub deflector, 30 psi water pressure, at a distance of 5 feet.

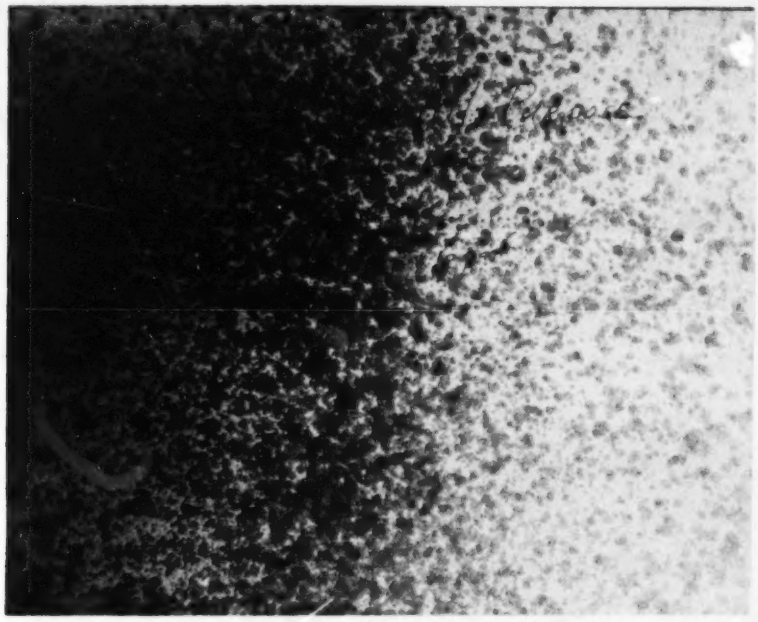

Figure 37. Spray pattern of the Melnor Deluxe All-Purpose Garden Gun when tested using the 6 setting, Wide deflector, 30 psi water pressure, at a distance of 5 feet.

Figure 38. Spray pattern of the Melnor Deluxe All-Purpose Garden Gun when tested using the 6 setting, Narrow deflector, 30 psi water pressure, at a distance of 5 feet.

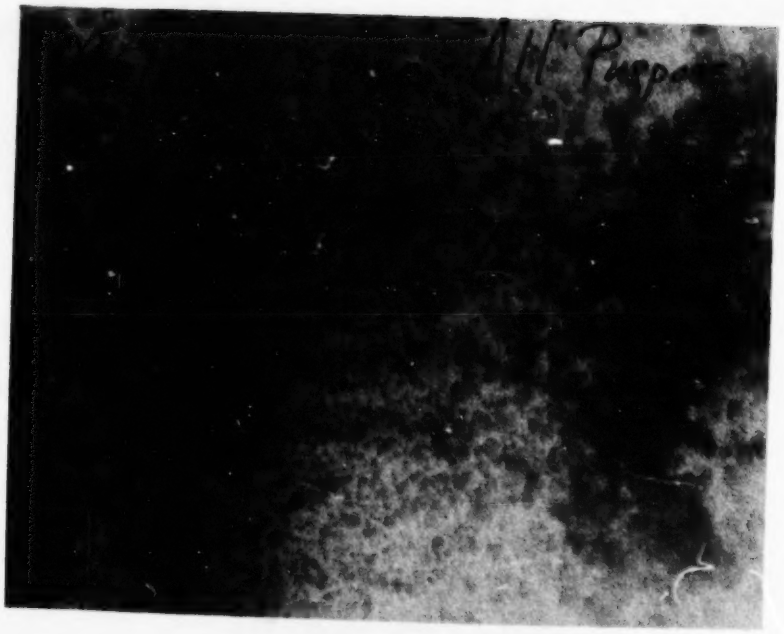

Figure 39. Spray pattern of the Melnor Deluxe All-Purpose Garden Gun when tested using the 15 setting, Shrub deflector, 30 psi water pressure, at a distance of 5 feet.

SECTION XX

VIGORO LAWN-WEED-N-FEED SPRAYER

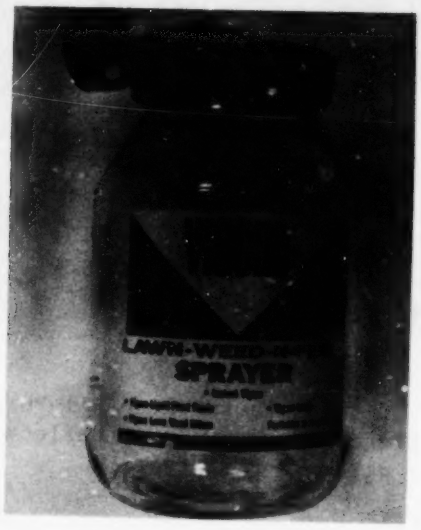

Figure 40. Vigoro Lawn-Weed-N-Feed Sprayer

Vigoro Lawn-Weed-N-Feed Sprayer (Figure 40) is distributed by Swift Chemical Company. It was designed for applying plant foods, herbicides, and lawn pesticides and fungicides, and has a maximum delivery capacity of 20 gallons of diluted spray.

Only a single sprayer unit was available for evaluation.

One hundred and fifty ml of $KMnO_4$ stock solution and 110 ml of water were put into the sprayer container for determining the delivery rate accuracy. The mean delivery rate values of 3 collections were 12.67, 14.33, and 14.83 ppm at 20, 30, and 40 psi water pressures respectively. The expected delivery rate value was 15.9 ppm. Delivery rate error of 20, 10, and 6% below the expected value resulted from water pressures 20, 30, and 40 psi respectively. The values in ppm below the expected value were 3.2, 1.6, and 1.1 ppm at 20, 30, and 40 psi water pressures respectively.

The mean volume of mixed spray delivered in 5 seconds was 1,210 ml and was equal to 3.84 U. S. gallons per minute.

The spray pattern of this sprayer is shown in Figure 41.

Figure 41. Spray pattern of Vigoro Lawn-Weed-N-Feed Sprayer when tested using 30 psi water pressure, at a distance of 5 feet.

Deficiencies of this sprayer are the absence of an on and off control and in order to mix the chemical with the emitted spray a finger must be placed over a control hole. Also this sprayer has a fixed spray deflector limiting spray direction.

SECTION XXI

BURGESS REDIMIX 2 GALLON HOSE-END WETTABLE POWDER SPRAYER

Figure 42. Burgess Redimix 2 Gallon Hose-end Wettable Powder Sprayer

Burgess Redimix 2 Gallon Hose-end Wettable Powder Sprayer (Figure 42) was not evaluated in this study; however, the existence of such sprayers should be acknowledged. This sprayer was designed to apply fungicides and other wettable powder chemicals to flowers, gardens, shrubs, lawns, and trees. This sprayer is manufactured by Burgess Vibrocrafters, Inc.

Table 1. Comparison between expected and actual delivery rate values of hose-end sprayers at three water pressures.

Sprayer Type	Expected ppm Value	20 psi water pressure			30 psi water pressure			40 psi water pressure		
		ppm Delivery Value	% Error	±[a] ppm Error	ppm Delivery Value	% Error	±[a] ppm Error	ppm Delivery Value	% Error	±[a] ppm Error
Ortho Spray-ette 4	7.9	5.8	-27	-2.1	6.9	-13	-1.0	7.1	-10	-0.8
Ortho Super Six Spray-ette	15.9	9.5	-40	-6.4	9.5	-40	-6.4	9.3	-42	-6.6
Ortho Lawn Sprayer	7.9	8.3	+5	+0.4	8.2	+4	+0.3	8.5	+8	+0.6
Ortho Lawn and Garden Sprayer										
(Down Soil and Soil)	15.9	6.7	-58	-9.2	6.7	-58	-9.2	6.8	-57	-9.1
(Down Foliage and Foliage)	15.9	14.9	-6	-1.0	15.2	-4	-0.7	15.3	-4	-0.6
Hayes Insecticide Sprayer No. 101	15.9	14.0	-12	-1.9	14.2	-11	-1.7	14.2	-11	-1.7
Hayes Flower Sprayer No. H-4	15.9	15.4	-3	-0.5	15.9	0	0.0	16.3	+3	+0.4
Hayes Soil and Turf Sprayer No. H-10	15.9	19.3	+21	+3.4	17.3	+9	+1.4	17.0	+7	+1.1
Hayes Fertilizer Sprayer No. 102	7.9	10.1	+28	+2.2	10.6	+34	+2.7	8.8	+11	+0.9
Miller's Six Shooter Hose-end Sprayer	15.9	15.2	-4	-0.7	13.9	-13	-2.0	13.3	-16	-2.6
Miller's Big 15 Hose-end Sprayer	15.9	15.6	-2	-0.3	16.3	+3	+0.4	16.9	+6	+1.0
Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer	15.9	15.9	0	0.0	16.7	+5	+0.8	16.9	+6	+1.0
Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer										
(6 gallon)	15.9	14.2	-11	-1.7	14.4	-9	-1.5	14.2	-11	-1.7
(15 gallon)	15.9	16.5	+4	+0.6	18.1	+14	+2.2	18.5	+16	+2.6
Big Andy 20 Gallon Fertilizer Sprayer No. A-21	7.9	13.6	+72	+5.7	14.5	+84	+6.6	16.2	+105	+8.3
Big Andy 6 Gallon Insecticide Sprayer No. A-7	15.9	17.0	+7	+1.1	17.9	+13	+2.0	17.7	+11	+1.8
Gilmour Air-O-Matic 362 Sprayer										
(1 setting)	7.9	0.0	-100	-7.9	4.5	-43	-3.4	10.3	+30	+2.4
(2 setting)	15.9	0.0	-100	-15.9	14.0	-12	-1.9	17.3	+9	+1.4
(3 setting)	23.8	15.7	-34	-8.1	20.2	-15	-3.6	22.3	-6	-1.5
(4 setting)	31.7	20.8	-34	-10.9	25.5	-20	-6.2	27.3	-14	-4.4
(5 setting)	39.6	25.8	-35	-13.8	38.0	-4	-1.6	40.3	+2	+0.7
(6 setting)	47.6	37.3	-22	-10.3	41.7	-12	-5.9	44.2	-7	-3.4
(7 setting)	55.5	47.8	-14	-7.7	49.5	-11	-6.0	50.5	-9	-5.0
(10 setting)	79.3	56.0	-29	-23.3	59.0	-26	-20.3	59.5	-25	-19.8

a: + = value above and - = value below the expected delivery value.

Table 2. Volume of mixed spray delivered per unit of time when using 30 psi (206.82 KPa) water pressure.

Sprayer Type	Mean ml Vol./5 sec.	Mean gallons per minute
Ortho Spray-ette 4	177	0.56
Ortho Super Six Spray-ette	158	0.50
Ortho Lawn Sprayer	1,055	3.34
Ortho Lawn and Garden Sprayer		
(Down Soil and Soil)	492	1.56
(Down Foliage and Foliage)	183	0.58
Hayes Insecticide Sprayer No. 101	185	0.59
Hayes Flower Sprayer No. H-4	175	0.55
Hayes Soil and Turf Sprayer No. H-10	885	2.81
Hayes Fertilizer Sprayer No. 102	875	2.77
Miller's Six Shooter Hose-end Sprayer	318	1.01
Miller's Big 15 Hose-end Sprayer	388	1.23
Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer	273	0.87
Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer		
(6 gallon)	287	0.91
(15 gallon)	445	1.41
Big Andy 20 Gallon Fertilizer Sprayer No. A-21	1,283	4.07
Big Andy 6 Gallon Insecticide Sprayer No. A-7	155	0.49
Gilmour Air-O-Matic 362 Sprayer		
(Setting 2)	360	1.14
(Setting 6)	375	1.19
(Setting 10)	380	1.20

Table 3. Delivery values of sprayers of the same type when using 20 psi (137.88 KPa) water pressure.

Sprayer Type	Mean ppm value			LSD[a] Value at 5% level
	Sprayer			
	1	2	3	
Ortho Spray-ette 4	5.67	6.67	5.00	0.48
Ortho Super Six Spray-ette	9.00	9.67	9.67	0.00
Ortho Lawn Sprayer	9.00	7.67	----	0.64
Ortho Lawn and Garden Sprayer				
(Down Soil and Soil)	6.33	7.33	6.33	0.72
(Down Foliage and Foliage)	14.00	15.00	15.67	0.48
Hayes Insecticide Sprayer No. 101	14.67	13.67	13.67	0.24
Hayes Flower Sprayer No. H-4	16.33	15.33	14.67	0.60
Hayes Soil and Turf Sprayer No. H-10	19.33	17.00	21.67	0.24
Hayes Fertilizer Sprayer No. 102	12.33	9.00	9.00	0.72
Miller's Six Shooter Hose-end Sprayer	15.33	15.33	15.00	0.72
Miller's Big 15 Hose-end Sprayer	15.33	15.00	16.33	0.72
Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer	14.67	17.33	15.67	1.44
Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer				
(6 gallon)	18.33	9.00	15.33	0.96
(15 gallon)	15.00	18.67	15.67	0.48
Big Andy 20 Gallon Fertilizer Sprayer No. A-21	13.33	11.67	15.67	1.32
Big Andy 6 Gallon Insecticide Sprayer No. A-7	19.33	15.00	16.67	1.20
Gilmour Air-O-Matic 362 Sprayer				
(1 setting)	0.00	0.00	0.00	0.00
(2 setting)	0.00	0.00	0.00	0.00
(3 setting)	14.50	17.00	15.50	2.37
(4 setting)	21.00	20.00	21.50	1.78
(5 setting)	26.00	25.50	26.00	1.19
(6 setting)	37.00	37.00	38.00	2.37
(7 setting)	50.00	45.00	48.50	5.34
(10 setting)	56.00	56.00	56.00	0.00

a = Least Significant Difference

Table 4. Delivery values of sprayers of the same type when using 30 psi (206.82 KPa) water pressure.

Sprayer Type	Mean ppm value			LSD[a] Value at 5% level
	Sprayer			
	1	2	3	
Ortho Spray-ette 4	6.67	7.33	6.67	1.68
Ortho Super Six Spray-ette	8.67	10.00	9.67	0.36
Ortho Lawn Sprayer	9.00	7.33	----	1.44
Ortho Lawn and Garden Sprayer				
(Down Soil and Soil)	6.67	7.00	6.33	0.72
(Down Foliage and Foliage)	14.67	15.33	15.67	0.72
Hayes Insecticide Sprayer No. 101	14.67	13.33	14.67	0.36
Hayes Flower Sprayer No. H-4	16.67	16.33	14.67	0.72
Hayes Soil and Turf Sprayer No. H-10	17.67	17.67	16.67	0.24
Hayes Fertilizer Sprayer No. 102	12.67	9.67	9.33	0.96
Miller's Six Shooter Hose-end Sprayer	13.67	14.00	14.00	0.72
Miller's Big 15 Hose-end Sprayer	16.33	15.67	17.00	0.48
Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer	16.33	17.67	16.00	0.48
Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer				
(6 gallon)	17.67	9.33	16.33	0.48
(15 gallon)	17.00	20.00	17.33	0.72
Big Andy 20 Gallon Fertilizer Sprayer No. A-21	13.67	13.00	16.67	1.20
Big Andy 6 Gallon Insecticide Sprayer No. A-7	19.67	14.67	19.33	2.28
Gilmour Air-O-Matic 362 Sprayer				
(1 setting)	6.00	7.50	0.00	2.97
(2 setting)	12.00	16.50	13.50	1.19
(3 setting)	19.00	21.00	20.50	0.00
(4 setting)	25.00	26.00	25.50	0.00
(5 setting)	37.50	39.00	37.50	2.37
(6 setting)	41.00	41.50	42.50	2.37
(7 setting)	48.50	50.00	50.00	1.19
(10 setting)	59.00	58.50	59.50	2.37

a = Least Significant Difference

Table 5. Delivery values of sprayers of the same type when using 40 psi (275.76 KPa) water pressure.

Sprayer Type	Mean ppm value			LSD[a] Value at 5% level
	Sprayer			
	1	2	3	
Ortho Spray-ette 4	6.67	7.67	7.00	1.20
Ortho Super Six Spray-ette	9.33	9.67	9.00	1.08
Ortho Lawn Sprayer	9.67	7.33	----	0.96
Ortho Lawn and Garden Sprayer				
(Down Soil and Soil)	7.00	7.00	6.33	1.20
(Down Foliage and Foliage)	15.00	15.00	16.00	0.24
Hayes Insecticide Sprayer No. 101	14.67	13.33	14.67	0.36
Hayes Flower Sprayer No. H-4	17.00	17.00	15.00	0.60
Hayes Soil and Turf Sprayer No. H-10	17.33	18.00	15.67	0.24
Hayes Fertilizer Sprayer No. 102	7.00	9.67	9.67	0.48
Miller's Six Shooter Hose-end Sprayer	13.00	13.00	14.00	0.72
Miller's Big 15 Hose-end Sprayer	17.00	16.33	17.33	0.96
Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer	16.67	17.67	16.33	0.72
Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer				
(6 gallon)	17.00	9.33	16.33	0.72
(15 gallon)	17.67	20.00	17.67	0.24
Big Andy 20 Gallon Fertilizer Sprayer No. A-21	14.00	14.67	20.00	0.96
Big Andy 6 Gallon Insecticide Sprayer No. A-7	21.33	14.33	17.00	2.16
Gilmour Air-O-Matic 362 Sprayer				
(1 setting)	9.50	9.00	12.50	2.97
(2 setting)	16.50	17.00	18.50	2.97
(3 setting)	21.50	22.50	23.00	1.19
(4 setting)	26.50	28.00	27.50	1.78
(5 setting)	39.00	40.50	41.50	1.19
(6 setting)	42.50	44.50	45.50	2.97
(7 setting)	49.50	50.50	51.50	3.56
(10 setting)	58.50	59.50	60.50	5.34

a = Least Significant Difference

Table 6. Delivery values of sprayer types when using three water pressures.

Sprayer Type	Mean[a] ppm Value			LSD[b] Value
	psi water pressure			at 5% level
	20	30	40	
Ortho Spray-ette 4	5.78	6.89	7.11	1.44
Ortho Super Six Spray-ette	9.45	9.45	9.33	1.28
Ortho Lawn Sprayer	8.34	8.17	8.50	4.22
Ortho Lawn and Garden Sprayer				
(Down Soil and Soil)	6.66	6.67	6.78	1.12
(Down Foliage and Foliage)	14.89	15.22	15.33	1.76
Hayes Insecticide Sprayer No. 101	14.00	14.22	14.22	1.77
Hayes Flower Sprayer No. H-4	15.44	15.89	16.33	2.72
Hayes Soil and Turf Sprayer No. H-10	19.33	17.34	17.00	3.84
Hayes Fertilizer Sprayer No. 102	10.11	10.56	8.78	4.48
Miller's Six Shooter Hose-end Sprayer	15.22	13.89	13.33	0.80
Miller's Big 15 Hose-end Sprayer	15.55	16.33	16.89	1.76
Burgess Redimix 6 Gallon Hose-end Plant, Shrub, and Tree Sprayer	15.89	16.67	16.89	2.72
Burgess 3 in 1 Redimix Hose-end All Purpose Sprayer				
(6 gallon)	14.22	14.44	14.22	8.80
(15 gallon)	16.45	18.11	18.45	4.32
Big Andy 20 Gallon Fertilizer Sprayer No. A-21	13.56	14.45	16.22	6.56
Big Andy 6 Gallon Insecticide Sprayer No. A-7	17.00	17.89	17.66	7.84
Gilmour Air-O-Matic 362 Sprayer				
(1 setting)	0.00	4.50	10.33	5.28
(2 setting)	0.00	14.00	17.33	3.12
(3 setting)	15.67	20.17	22.33	2.88
(4 setting)	20.83	25.50	27.33	1.92
(5 setting)	25.83	38.00	40.33	2.16
(6 setting)	37.33	41.67	44.17	2.64
(7 setting)	47.83	49.50	50.50	4.08
(10 setting)	56.00	59.00	59.50	1.44

a = Mean of 3 sprayers except Ortho Lawn Sprayer which was a mean of 2 sprayers.

b = Least Significant Difference.